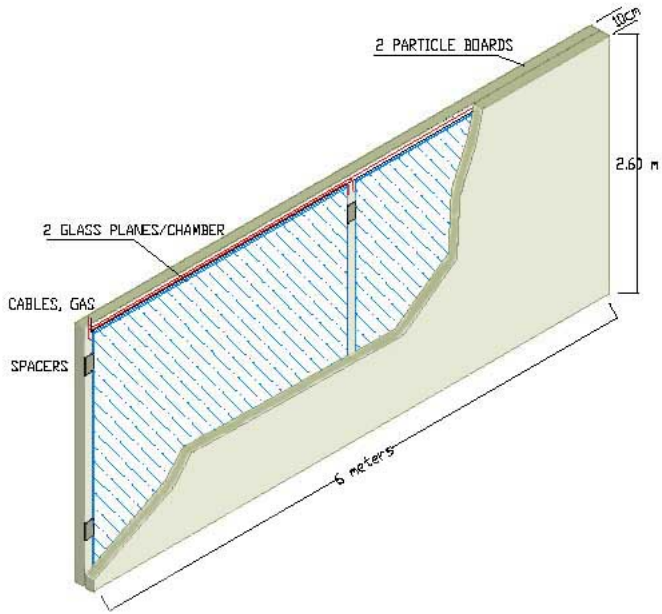
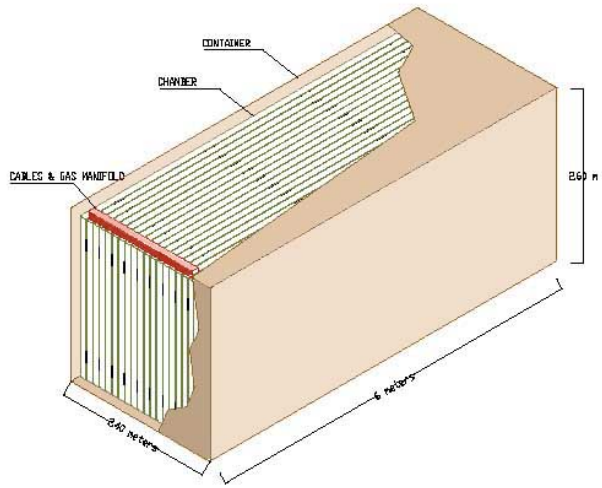
A guide to a containerized RPC detector

- Simple, reliable, easy to build detectors
- Uniform response over the entire volume
- Fast response. Event integration time 100 nsec.
- Relatively small modules to build and handle
- Utilize industrial solution for construction of a huge detector volume
- Minimal testing/calibration/integration/installation necessary
- Access/replace ALL detector elements (new)
- Relatively simple and inexpensive transport
- Wide range of environmental conditions acceptable
- (relatively) Inexpensive

A. Para
2nd NuMI Off-axis workshop

- Detector ‘element’
  - 10 + 10 cm thick, 2.4 x 6 m particle board
  - 2 RPC chambers 2.4 x 3 m, 2 mm gap
  - 3 cm strips: 200X + 80Y channels
- Container:
  - 12 detector elements
  - 23.2 t particle board, 1.5 t of glass, 2 t of steel = 26.7 t total
  - 3360 electronics channels
  - 24 RPC chambers, 172.8 m^2

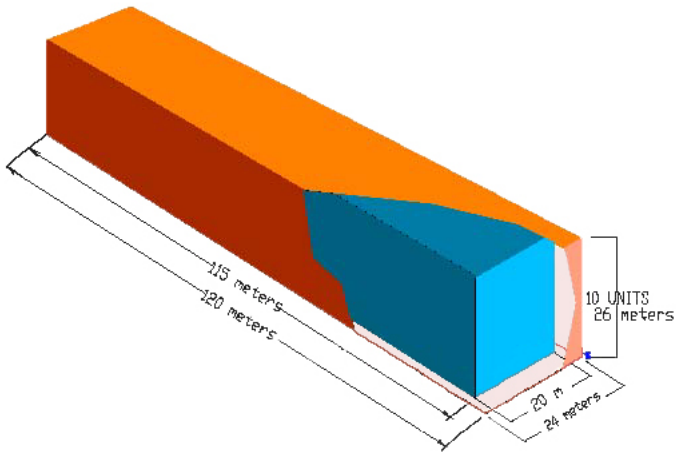




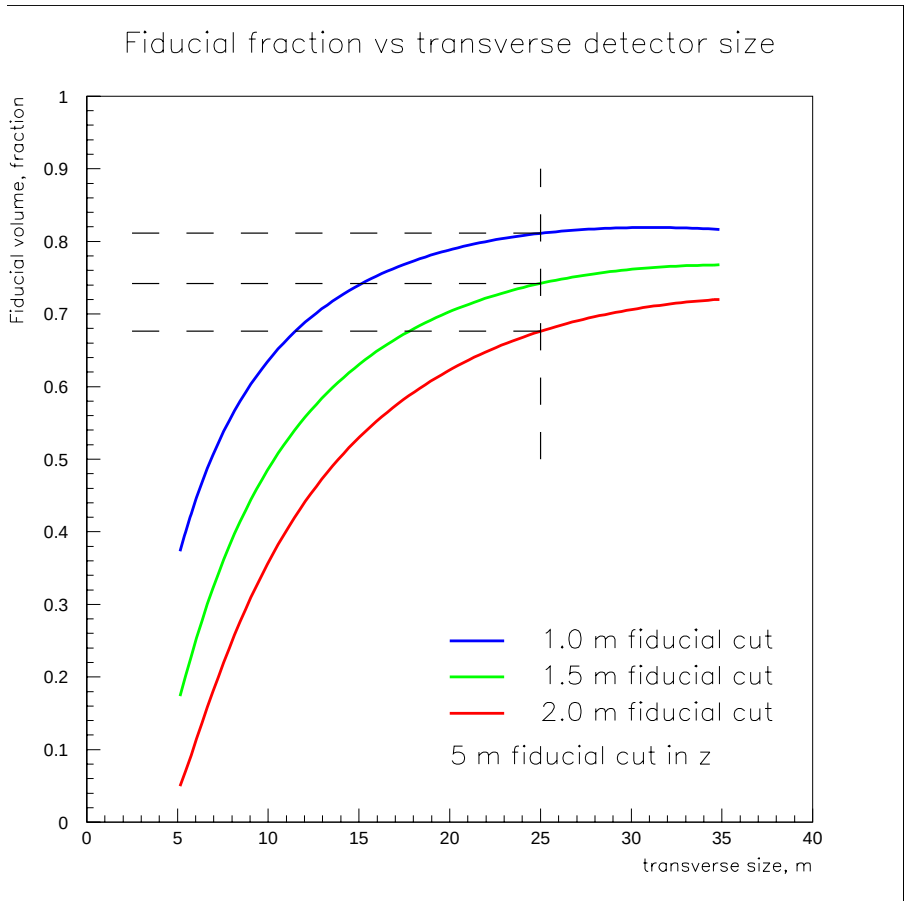
Detector in numbers

- 24 x 24.5 x 130 m
- 1/3 X_o sampling in X and in Y
- 3 cm transverse sampling
- 2000 containers:
  - 4 x 10 x 50 containers ‘cube’
  - 53.5 kton
  - 46.4 kton of particle boards
  - 6,720,000 electronics channels
  - 48000 chambers, 350,000 m^2
  - 750 m^3 of gas

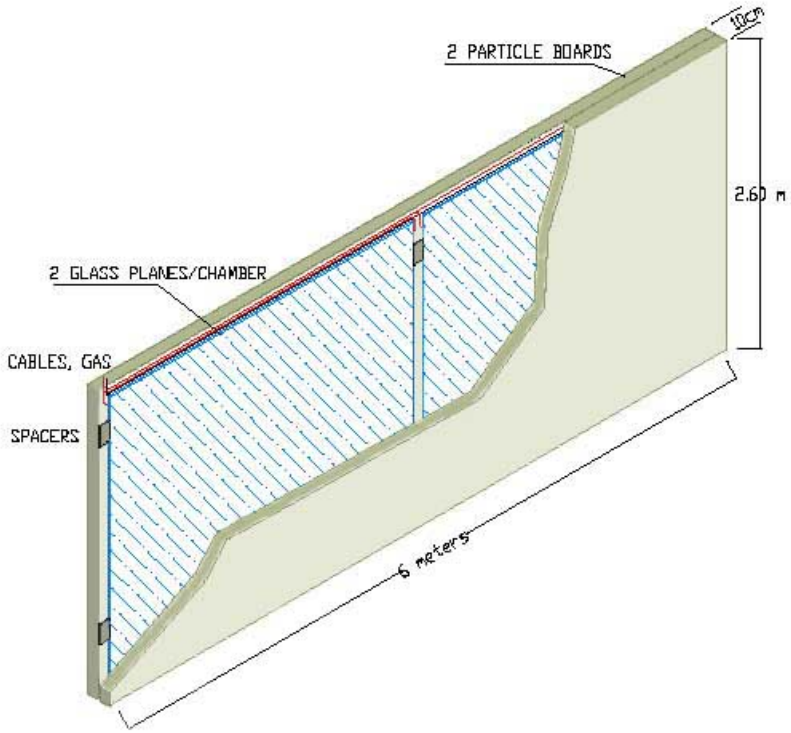
Event containment and fiducial volume issues

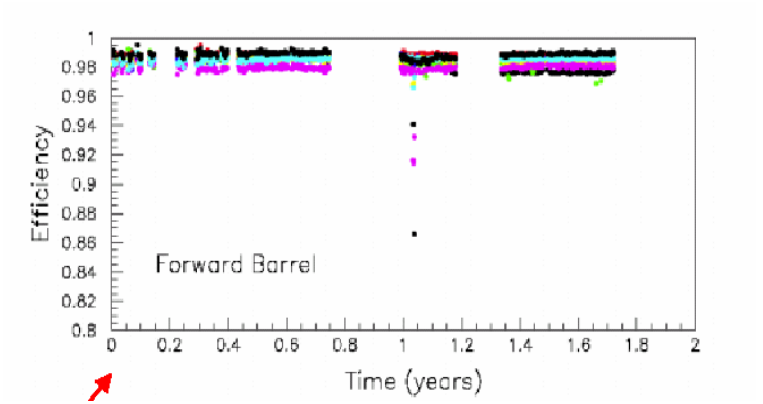


- Need to evaluate the necessary fiducial cut
- 25 x 25 m^2 detector has fiducial volume of 66 – 82%, depending on the fiducial cut



Chambers





- Glass RPC, BELLE (Virginia Tech) design
- Robust, efficient, dependable
- BELLE: 5 years of operations, 5,000 m^2. Total number of replaced chambers : ZERO

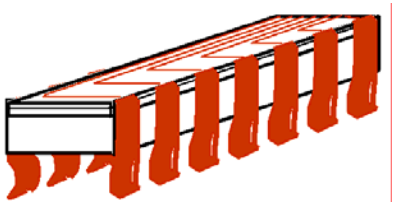
Off-axis detector:

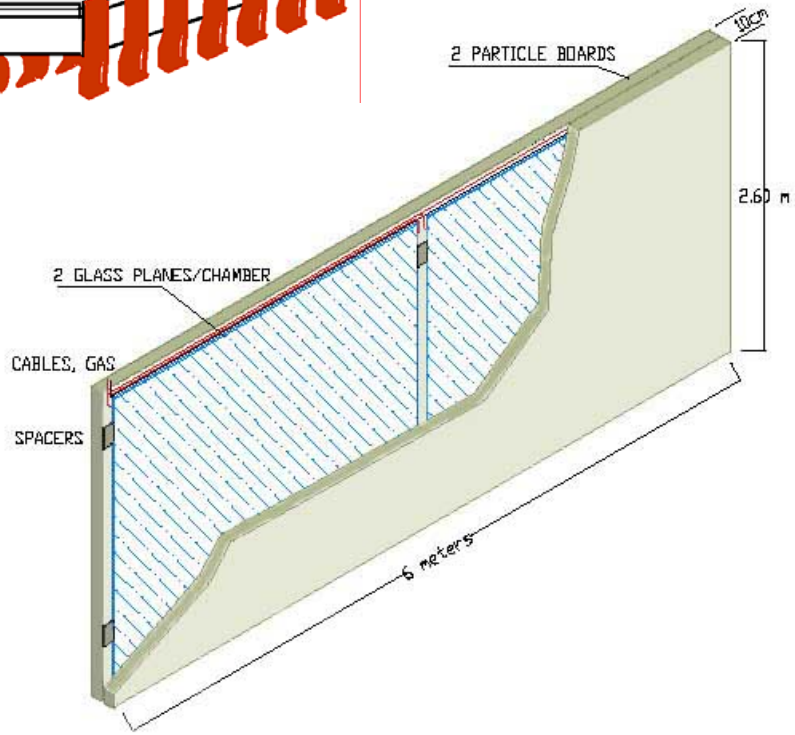
- 48,000 chambers
- 345,600 m2

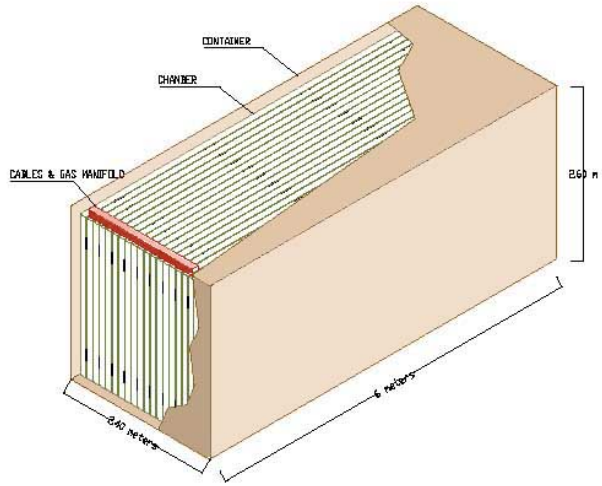
Cost $16.8M + $5M

See N. Morgan/A. Para

Absorber







- RPC sandwiched between 10 cm thick laminates of particle boards
- X and Y readout strips glued on the particle board
- Mass terminator/connector with front-end board. No cables!
- HV/gas manifold in a container: minimal number of external connections

Complete detector:

•24,000 elements

•46.4 kton of absorber

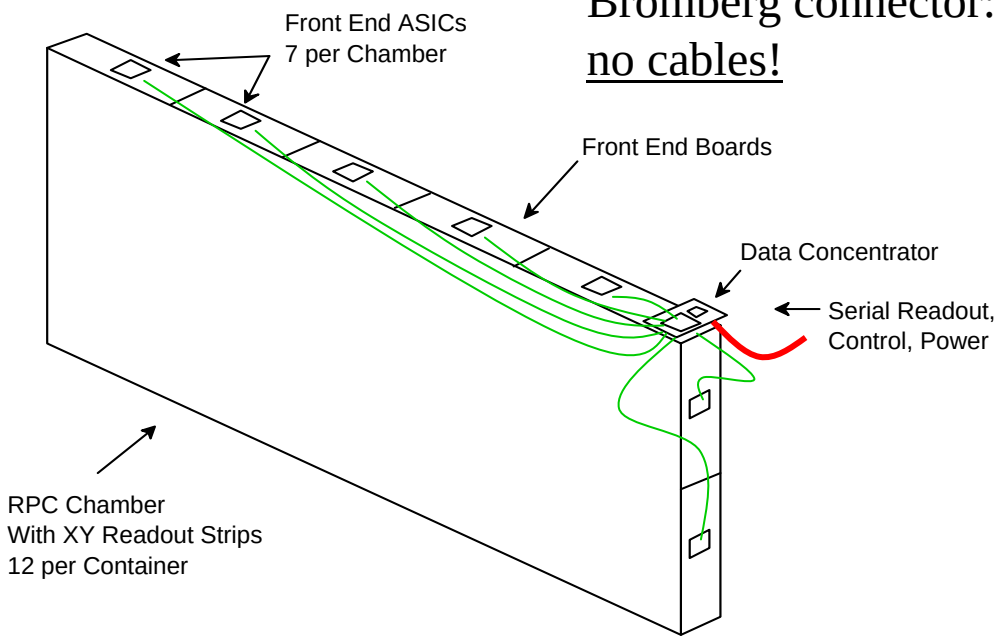
Cost (material + labor): $15.5 M

See C.Bromberg/ J. Grudzinski/V. Guarino

Front End Electronics (per plane)

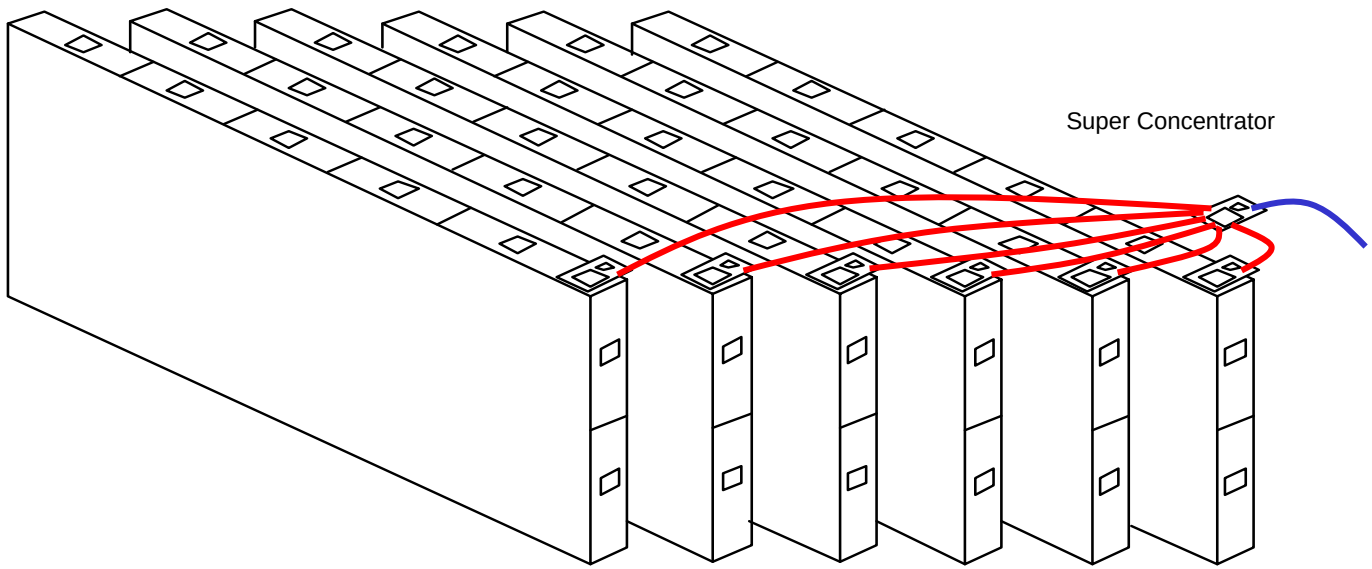
- 200 Y Strips/Plane, 80 X Strips/Plane
- Use 40 Ch/Chip → 7 Chips/Plane
- Each ASIC Resides on a Printed Circuit Board → 7 FE Boards/Plane
- 1 Data Concentrator per Plane – Collects Data from 7 Front End Chips
- Each Data Concentrator Resides on a Separate PCB on Plane

Bromberg connector: no cables!



Fron End Electronics (container)

- 12 Planes/Container
- 1 “Super” Concentrator per Container
- Use VECSEL Optical Drivers w/Fiber for Output



(6 of 12 Planes Shown)

Electronics System Architecture

Back End: VME

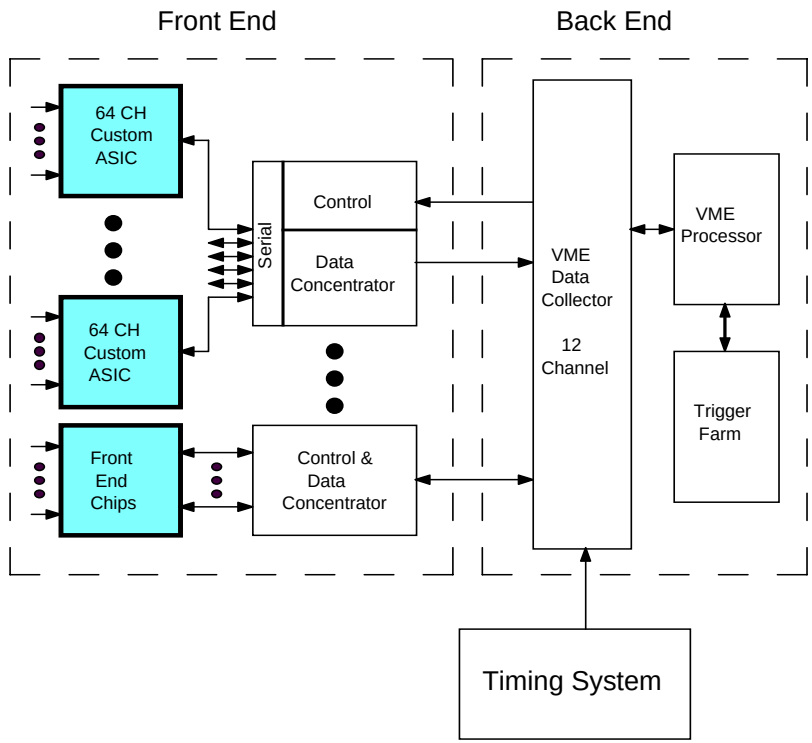
6,720,000 chanels

Dead-timeless

Trigerless

Cost: $18.5M + $6M contingency

G. Drake/ Ch. Nelson



High Voltage

- Chambers need ~ 8.2 kV (5.6 if 1 mm gap)
- Dark current a very sensitive indicator of an onset of potential troubles
- Need current measurement, HV adjustment capability per chamber, 48,000 chanels

Cockroft-Walton PS

No HV connectors

Full computer control/feedback

$4M + $1M contingency

See R. Talaga

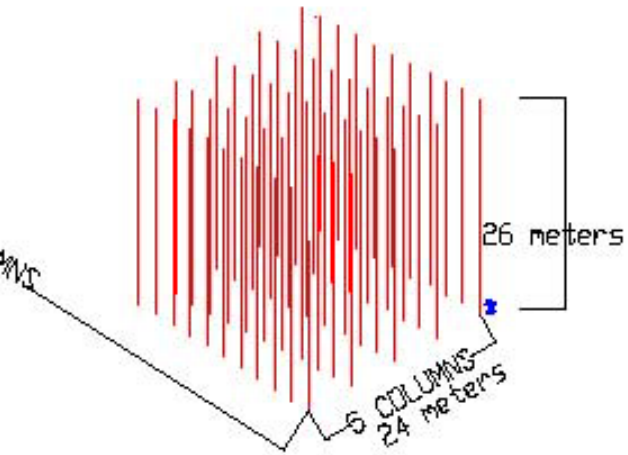
Ship fully functional, checked out containers to the detector site

Off-axis detector:

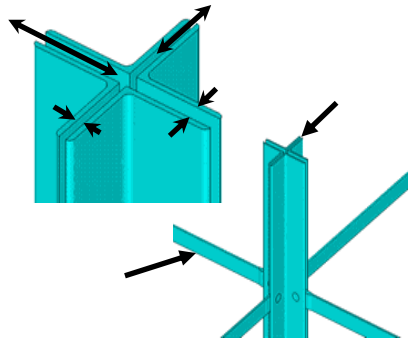
2000 containers. Cost dependent on the location. Estimate : $5.4 M + $1.6 M contingency

See J. Cooper

Rapid installation



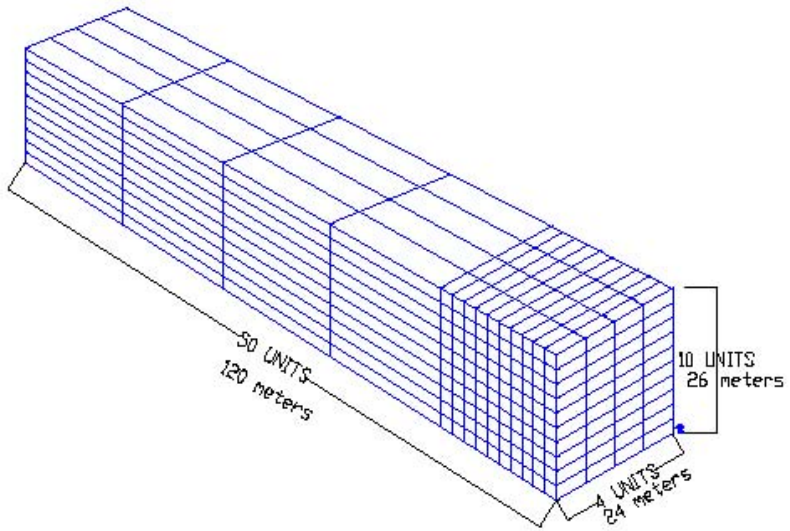
- Cell guides forming vertical chanels for rapid assembly (2 containers/min!)
- 200 ‘towers’ 10 containers high each



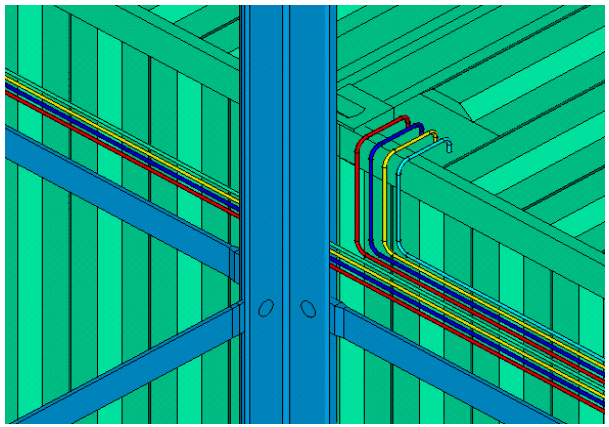
Cell guides (aluminium) construction:

$1.405 M + $0.573 contingency

See J. Cooper/J. Kilmer/B. Wands

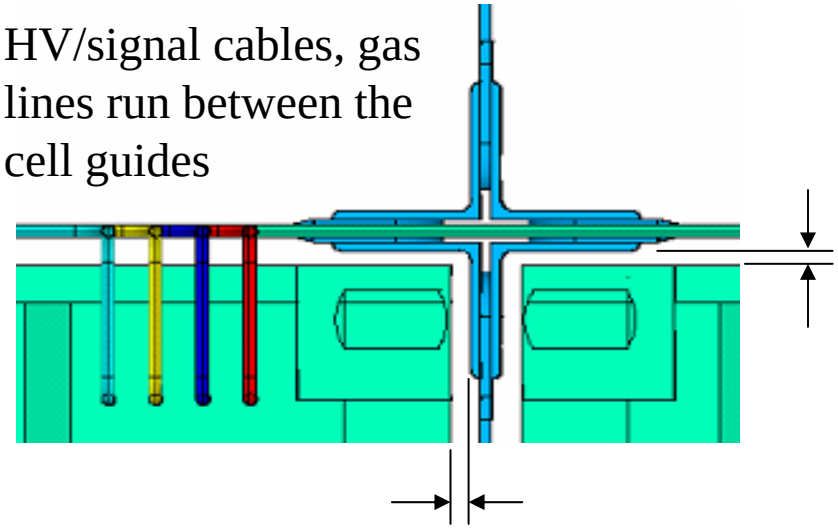


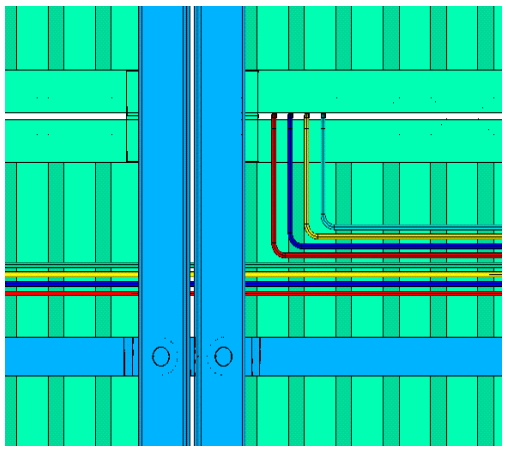
Installation in practice: cable/gas hookup



Gas/cable connectors located in top corner of the container

HV/signal cables, gas lines run between the cell guides





1” vertical gap between containers protects cables from being crushed

J. Cooper/J.Kilmer/B. Wands

Gas system

750 m3 of gas

One volume exchange per day

No water vapor (< 10 ppm)

Re-circulate

Overpressure protection (5 cm of water)

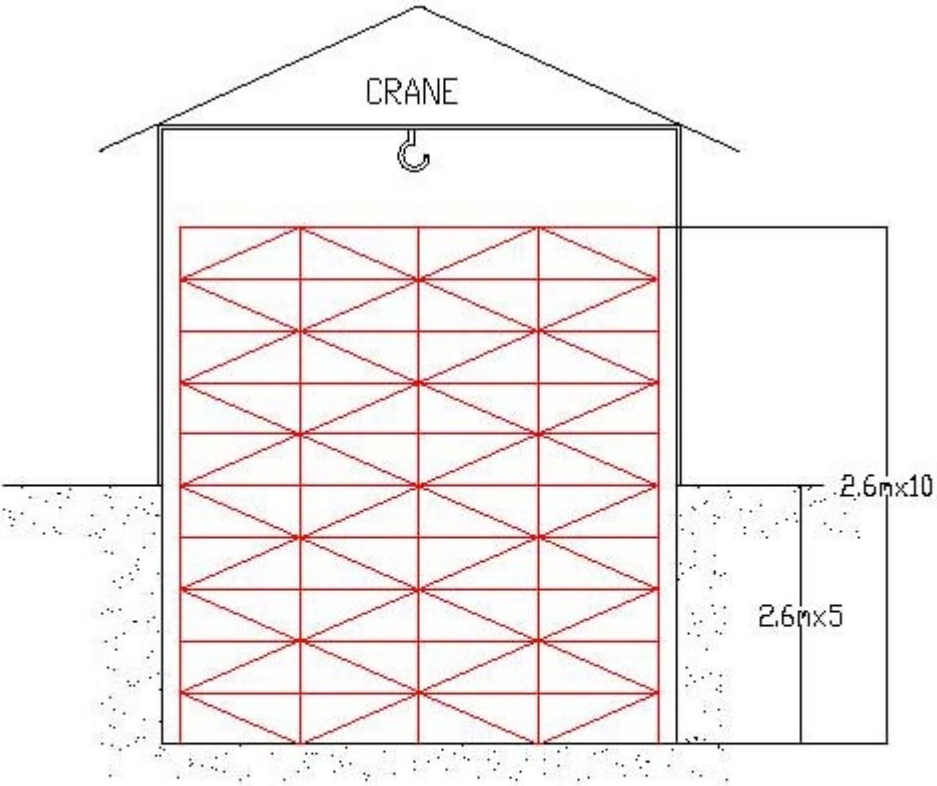
One gas inlet/outlet per container

I. Ambats/ R. Schmitt

No real estimate yet.

Ignorant's guess: less that $4M + $1M contingency

Insurance policy: Repair/exchange procedure (not really expected to be used)



EXPERIMENTAL HALL, FRONT VIEW

1) 5 COLUMNS, EACH of 4 "L's"

2) CONNECTED BY HORIZONTAL BEAMS, 'U' SHAPE, ALSO USED AS CABLE TRAYS

Suppose the chamber/electronics fails in the bottom container:

- Unplug the top containers form the top, remove them
- Replace the container
- Install the containers above it

Replacement time dominated by disconnect/reconnect procedure. Few hours??

Detector cost, general remarks

- Need materials, labor and contingency
- Need uniform labor costs for all proposed detectors
- Real labor costs may/hopefully will be lower than those necessary for the review process
- In the following the labor cost is assumed to be 40-50$/hour

	Materials	Labor	Contingency	
Building	21,800		5,000	24,132+5,264
catwalks	444	88	264	
RTG crane	1,800			
Cell guides	512	893	573	5,912+2,173
Containers	5,400		1,600	
Absorber	11,400	3,000	4,000	14,400+4,000
RPC chambers	9,500	8,400	5,000	
HV	4,000		1,000	44,400+13,000
Electronics	18,500		6,000	
Gas system	4,000		1,000	
DAQ, slow control	3,000		1,000	3,000+1,000
Total				91,874+25,437

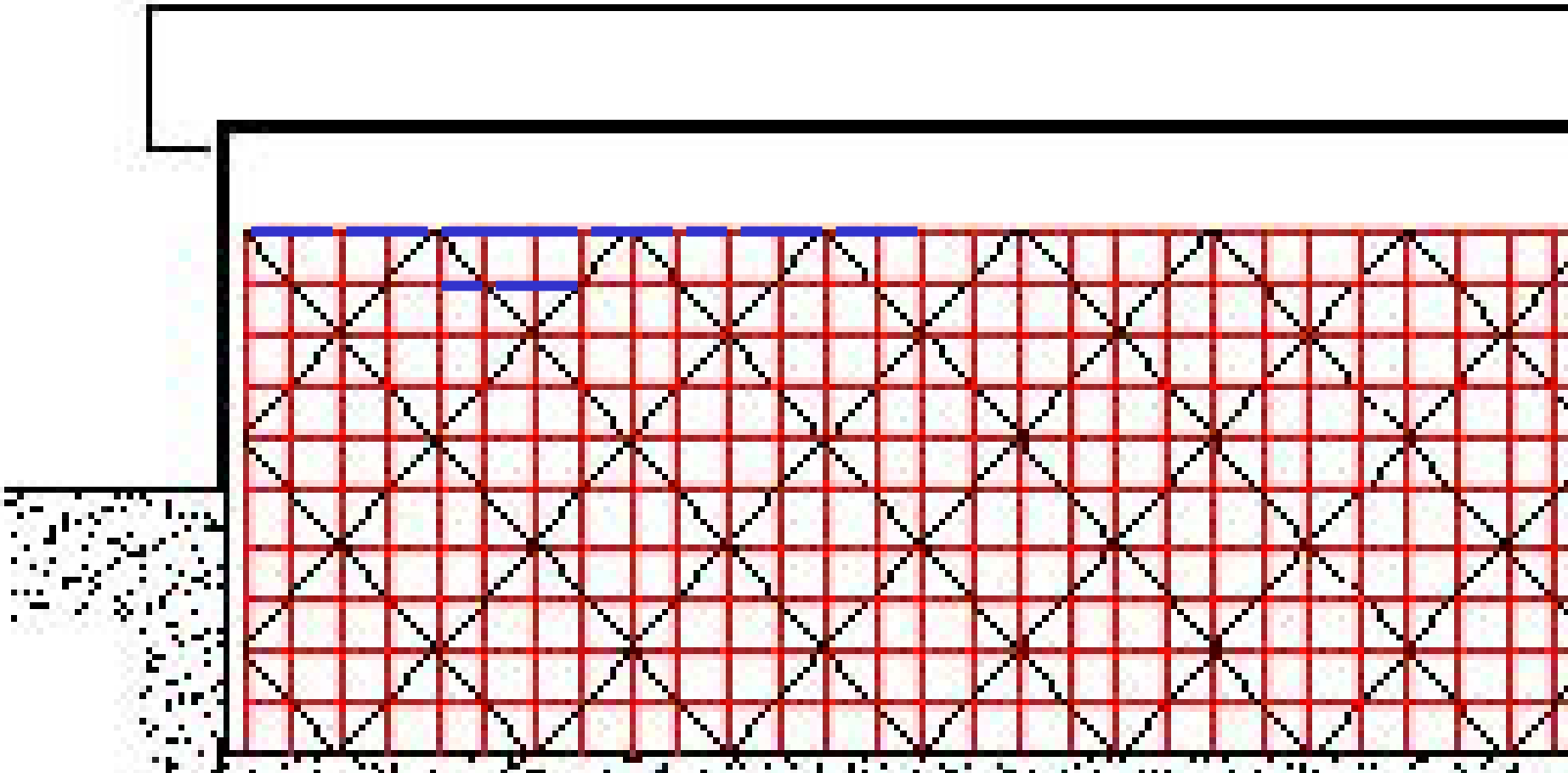
Some observations

- Cost distributed across several components. Active detector cost account for about a half of the total
- Installation/integration costs virtually absent for this scenario
- Electronics a very significant fraction of the active detector cost. 3 cm readout strip assumed. Need to re-evaluate.
- Tradeoff between longitudinal sampling and detector costs needs to be studied. (Example: reduce sampling by a factor of two and save less than 25% of the cost. The loss of FOM of 16% is equivalent to a loss of 32% of the detector mass)
- Increase of the transverse dimensions to 30 x 30 meters is relatively straightforward and probably desirable

Veto shield?

If necessary: insert a chamber at the ceiling of the container in top layer (two top layers? three top layers?) of the containers

- Does not interfere with the container replacement scheme



Conclusions

- Glass RPC + particle board + shipping containers offer a practical solution to a problem of constructing a huge volume detector
- Detector is modular with fundamental building blocks relatively simple to construct
- Industrial solutions used to solve the challenging problem of scale
- Detector well suited for construction at a distributed centers
- Realistic 50 kton detector can be constructed for ~$100M (+ contingency)
- A complete detector design in progress, should be ready for a serious review by the summer